Project_1_App_Rating_Prediction

April 7, 2021

1 Project 1 - App Rating Prediction

1.1 Step 1 : Load the data file using pandas.

Import the Necessary Libraries

[1]:
```
import pandas as pd
import numpy as np
import zipfile
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn import datasets, linear_model
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from math import sqrt
from sklearn.metrics import mean_squared_error
```

[2]:
```
with zipfile.ZipFile('1569582940_googleplaystore.zip','r') as zip_ref:
    zip_ref.extractall('Project 1 - App Rating Prediction')
```

[3]:
```
gdata = pd.read_csv("Project 1 - App Rating Prediction/googleplaystore.csv")
gdata.head()
```

[3]:
```
                                                 App        Category  Rating  \
0     Photo Editor & Candy Camera & Grid & ScrapBook  ART_AND_DESIGN     4.1
1                                Coloring book moana  ART_AND_DESIGN     3.9
2  U Launcher Lite - FREE Live Cool Themes, Hide …  ART_AND_DESIGN     4.7
3                              Sketch - Draw & Paint  ART_AND_DESIGN     4.5
4              Pixel Draw - Number Art Coloring Book  ART_AND_DESIGN     4.3

  Reviews  Size     Installs  Type Price Content Rating  \
0      159   19M      10,000+  Free     0       Everyone
1      967   14M     500,000+  Free     0       Everyone
2    87510  8.7M   5,000,000+  Free     0       Everyone
3   215644   25M  50,000,000+  Free     0           Teen
4      967  2.8M     100,000+  Free     0       Everyone

                      Genres      Last Updated         Current Ver  \
0               Art & Design   January 7, 2018               1.0.0
```

```
1  Art & Design;Pretend Play  January 15, 2018              2.0.0
2                Art & Design    August 1, 2018              1.2.4
3                Art & Design      June 8, 2018  Varies with device
4    Art & Design;Creativity     June 20, 2018                 1.1

    Android Ver
0  4.0.3 and up
1  4.0.3 and up
2  4.0.3 and up
3    4.2 and up
4    4.4 and up
```

1.2 Step 2 : Check for null values in the data. Get the number of null values for each column.

[4]:

```
gdata.isna().sum()
```

[4]:

```
App                  0
Category             0
Rating            1474
Reviews              0
Size                 0
Installs             0
Type                 1
Price                0
Content Rating       1
Genres               0
Last Updated         0
Current Ver          8
Android Ver          3
dtype: int64
```

1.3 Step 3 : Drop records with nulls in any of the columns.

[5]:

```
gdata1 = gdata.dropna()
gdata1
```

[5]:

```
                                                     App             Category  \
0         Photo Editor & Candy Camera & Grid & ScrapBook       ART_AND_DESIGN
1                                    Coloring book moana       ART_AND_DESIGN
2      U Launcher Lite – FREE Live Cool Themes, Hide …       ART_AND_DESIGN
3                                  Sketch - Draw & Paint       ART_AND_DESIGN
4                  Pixel Draw - Number Art Coloring Book       ART_AND_DESIGN
…                                                      …                  …
10834                                      FR Calculator               FAMILY
10836                                   Sya9a Maroc - FR               FAMILY
10837                  Fr. Mike Schmitz Audio Teachings               FAMILY
```

```
10839                      The SCP Foundation DB fr nn5n  BOOKS_AND_REFERENCE
10840      iHoroscope - 2018 Daily Horoscope & Astrology            LIFESTYLE

       Rating Reviews                Size     Installs  Type Price  \
0         4.1     159                 19M      10,000+  Free     0
1         3.9     967                 14M     500,000+  Free     0
2         4.7   87510                8.7M   5,000,000+  Free     0
3         4.5  215644                 25M  50,000,000+  Free     0
4         4.3     967                2.8M     100,000+  Free     0
…       …     …                 …          …   …   …
10834     4.0       7                2.6M         500+  Free     0
10836     4.5      38                 53M       5,000+  Free     0
10837     5.0       4                3.6M         100+  Free     0
10839     4.5     114  Varies with device       1,000+  Free     0
10840     4.5  398307                 19M  10,000,000+  Free     0

      Content Rating                     Genres      Last Updated  \
0           Everyone             Art & Design   January 7, 2018
1           Everyone  Art & Design;Pretend Play  January 15, 2018
2           Everyone             Art & Design    August 1, 2018
3               Teen             Art & Design      June 8, 2018
4           Everyone    Art & Design;Creativity     June 20, 2018
…              …                        …               …
10834       Everyone                Education     June 18, 2017
10836       Everyone                Education     July 25, 2017
10837       Everyone                Education      July 6, 2018
10839     Mature 17+         Books & Reference  January 19, 2015
10840       Everyone                Lifestyle     July 25, 2018

              Current Ver         Android Ver
0                   1.0.0        4.0.3 and up
1                   2.0.0        4.0.3 and up
2                   1.2.4        4.0.3 and up
3      Varies with device          4.2 and up
4                     1.1          4.4 and up
…                   …                 …
10834               1.0.0          4.1 and up
10836                1.48          4.1 and up
10837                 1.0          4.1 and up
10839  Varies with device  Varies with device
10840  Varies with device  Varies with device

[9360 rows x 13 columns]
```

[6]:

```
gdata1.isna().sum()
```

[6]:

```
App               0
Category          0
Rating            0
Reviews           0
Size              0
Installs          0
Type              0
Price             0
Content Rating    0
Genres            0
Last Updated      0
Current Ver       0
Android Ver       0
dtype: int64
```

[7]:

```
gdata1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 9360 entries, 0 to 10840
Data columns (total 13 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   App             9360 non-null   object
 1   Category        9360 non-null   object
 2   Rating          9360 non-null   float64
 3   Reviews         9360 non-null   object
 4   Size            9360 non-null   object
 5   Installs        9360 non-null   object
 6   Type            9360 non-null   object
 7   Price           9360 non-null   object
 8   Content Rating  9360 non-null   object
 9   Genres          9360 non-null   object
 10  Last Updated    9360 non-null   object
 11  Current Ver     9360 non-null   object
 12  Android Ver     9360 non-null   object
dtypes: float64(1), object(12)
memory usage: 1023.8+ KB
```

1.4 Step 4 : Variables seem to have incorrect type and inconsistent formatting. You need to fix them:

1.4.1 Step 4 Substep 1 : Size column has sizes in Kb as well as Mb. To analyze, you'll need to convert these to numeric.

Step 4 Substep 1 Part 1: Extract the numeric value from the column

[8]:

```
gdata1['Size'].head()
```

```
[8]: 0     19M
     1     14M
     2    8.7M
     3     25M
     4    2.8M
     Name: Size, dtype: object
```

```
[9]: gdata1['Size_1'] = gdata1.Size.replace(['Varies with device'],[''])
     gdata1['Size_1'].head()
```

```
<ipython-input-9-56d83f83fa4f>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_1'] = gdata1.Size.replace(['Varies with device'],[''])
```

```
[9]: 0     19M
     1     14M
     2    8.7M
     3     25M
     4    2.8M
     Name: Size_1, dtype: object
```

```
[10]: gdata1['Size_2'] = gdata1.Size_1.replace(r'[KM]+$', '', regex=True)
      gdata1['Size_2'].head()
```

```
<ipython-input-10-1d243f58ff1d>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_2'] = gdata1.Size_1.replace(r'[KM]+$', '', regex=True)
```

```
[10]: 0     19
      1     14
      2    8.7
      3     25
      4    2.8
      Name: Size_2, dtype: object
```

1.4.2 Step 4 Substep 1 Part 2: Multiply the value by 1,000, if size is mentioned in Mb

[11]:

```
gdata1['Size_3'] = gdata1.Size_1.str.extract(r'[\d\.]+([KM]+)', expand=False).
 ↪replace(['M'], [10**3])
gdata1['Size_3'].head()
```

```
<ipython-input-11-fe5639da0229>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_3'] = gdata1.Size_1.str.extract(r'[\d\.]+([KM]+)',
expand=False).replace(['M'], [10**3])
```

[11]:

```
0    1000.0
1    1000.0
2    1000.0
3    1000.0
4    1000.0
Name: Size_3, dtype: float64
```

[12]:

```
gdata1['Size_4'] = gdata1['Size'].astype(str).str.extract("([-+]?\d*\.\d+|[-+]?
 ↪\d+)").astype(float)
gdata1['Size_4'].head()
```

```
<ipython-input-12-c0bfb0ff662f>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_4'] =
gdata1['Size'].astype(str).str.extract("([-+]?\d*\.\d+|[-+]?\d+)").astype(float)
```

[12]:

```
0    19.0
1    14.0
2     8.7
3    25.0
4     2.8
Name: Size_4, dtype: float64
```

[13]:

```
gdata1['Size_5'] = gdata1['Size_4']*gdata1['Size_3']
gdata1['Size_5'].head()
```

```
<ipython-input-13-78d8026e72e0>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_5'] = gdata1['Size_4']*gdata1['Size_3']
```

[13]:

```
0    19000.0
1    14000.0
2     8700.0
3    25000.0
4     2800.0
Name: Size_5, dtype: float64
```

[14]:

```
gdata1['Size_5'].isnull().sum()
```

[14]:

```
1894
```

[15]:

```
gdata1['Size_5'] = gdata1['Size_5'].fillna(np.mean(gdata1['Size_5']))
```

```
<ipython-input-15-b01939123037>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Size_5'] = gdata1['Size_5'].fillna(np.mean(gdata1['Size_5']))
```

[16]:

```
gdata1['Size_5'].isnull().sum()
```

[16]:

```
0
```

1.4.3 Step 4 Substep 2 : Reviews is a numeric field that is loaded as a string field. Convert it to numeric (int/float).

[17]:

```
gdata1['Reviews'].head()
```

[17]:

```
0       159
1       967
2     87510
3    215644
4       967
Name: Reviews, dtype: object
```

[18]:

```
gdata1['Reviews_1'] = gdata1['Reviews'].astype(int)
gdata1['Reviews_1'].head()
```

```
<ipython-input-18-eaa80f916e2f>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Reviews_1'] = gdata1['Reviews'].astype(int)
```

[18]:
```
0       159
1       967
2     87510
3    215644
4       967
Name: Reviews_1, dtype: int32
```

1.4.4 Step 4 Substep 3 : Installs field is currently stored as string and has values like 1,000,000+.

Step 4 Substep 3 Part 1 : Treat 1,000,000+ as 1,000,000

[19]:
```
gdata1['Installs'].head()
```

[19]:
```
0        10,000+
1       500,000+
2     5,000,000+
3    50,000,000+
4       100,000+
Name: Installs, dtype: object
```

Step 4 Substep 3 Part 2 : remove '+', ',' from the field, convert it to integer

[20]:
```
gdata1.Installs.dtype
```

[20]:
```
dtype('O')
```

[21]:
```
gdata1['Installs_1'] = gdata1['Installs'].replace({'[,+]':''},regex=True)
```

```
<ipython-input-21-0362b8a8424a>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Installs_1'] = gdata1['Installs'].replace({'[,+]':''},regex=True)
```

[22]:
```
gdata1['Installs_1'] = gdata1['Installs_1'].astype(int)
gdata1['Installs_1'].head()
```

```
<ipython-input-22-c2247b7bc345>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Installs_1'] = gdata1['Installs_1'].astype(int)
```

```
[22]: 0        10000
      1       500000
      2      5000000
      3     50000000
      4       100000
      Name: Installs_1, dtype: int32
```

Step 4 Substep 4 : Price field is a string and has $ symbol. Remove '$' sign, and convert it to numeric.

```
[23]: gdata1['Price'][220:224]
```

```
[23]: 232        0
      233        0
      234    $4.99
      235    $4.99
      Name: Price, dtype: object
```

```
[24]: type(gdata1['Price'])
```

```
[24]: pandas.core.series.Series
```

```
[25]: gdata1['Price_1'] = gdata1['Price'].astype(str).str.extract("([-+]?\d*\.
       ↪\d+|[-+]?\d+)$").astype(float)
      gdata1['Price_1'][220:224]
```

```
<ipython-input-25-88b29b379534>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['Price_1'] = gdata1['Price'].astype(str).str.extract("([-+]?\d*\.\d+|[-
+]?\d+)$").astype(float)
```

```
[25]: 232    0.00
      233    0.00
      234    4.99
      235    4.99
      Name: Price_1, dtype: float64
```

1.4.5 Step 4 Substep 5 : Sanity checks:

Step 4 Substep 5 Part 1 : Average rating should be between 1 and 5 as only these values are allowed on the play store. Drop the rows that have a value outside this range.

```
[26]: max(gdata1['Rating'])
```

```
[26]: 5.0
```

```
[27]: min(gdata1['Rating'])
```

```
[27]: 1.0
```

Step 4 Substep 5 Part 2 : Reviews should not be more than installs as only those who installed can review the app. If there are any such records, drop them.

```
[28]: gdata1['Reviews_1'].head()
```

```
[28]: 0       159
      1       967
      2     87510
      3    215644
      4       967
      Name: Reviews_1, dtype: int32
```

```
[29]: gdata1['Installs_1'].head()
```

```
[29]: 0       10000
      1      500000
      2     5000000
      3    50000000
      4      100000
      Name: Installs_1, dtype: int32
```

```
[30]: gdata1['rgti'] = gdata1['Reviews_1']>gdata1['Installs_1']
      gdata1['rgti'].head()
```

```
<ipython-input-30-90b759d6361b>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata1['rgti'] = gdata1['Reviews_1']>gdata1['Installs_1']
```

```
[30]: 0    False
      1    False
      2    False
      3    False
      4    False
      Name: rgti, dtype: bool
```

```
[31]: gdata1.rgti[gdata1.rgti].index
```

```
[31]: Int64Index([2454, 4663, 5917, 6700, 7402, 8591, 10697], dtype='int64')
```

```
[32]: gdata1.loc[6700]
```

[32]:
```
App                 Brick Breaker BR
Category                        GAME
Rating                           5.0
Reviews                            7
Size                             19M
Installs                          5+
Type                            Free
Price                              0
Content Rating              Everyone
Genres                        Arcade
Last Updated           July 23, 2018
Current Ver                      1.0
Android Ver               4.1 and up
Size_1                           19M
Size_2                            19
Size_3                        1000.0
Size_4                          19.0
Size_5                       19000.0
Reviews_1                          7
Installs_1                         5
Price_1                          0.0
rgti                            True
Name: 6700, dtype: object
```

[33]:
```
gdata2 = gdata1.drop([2454, 4663, 5917, 6700, 7402, 8591, 10697])
gdata2.rgti[gdata2.rgti].index
```

[33]:
```
Int64Index([], dtype='int64')
```

Step 4 Substep 5 Part 3 : For free apps (type = "Free"), the price should not be >0. Drop any such rows.

[34]:
```
gdata3 = gdata2[gdata2['Type'] == 'Free']
```

[35]:
```
gdata3['Price_1'] = gdata3['Price'].astype(int)
```

```
<ipython-input-35-a88d5396de22>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata3['Price_1'] = gdata3['Price'].astype(int)
```

[36]:
```
gdata3['FPrice'] = gdata3['Price_1'] > 0
gdata3.FPrice[gdata3.FPrice].index
```

```
<ipython-input-36-98ce50919975>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
```

```
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  gdata3['FPrice'] = gdata3['Price_1'] > 0
```

```
[36]: Int64Index([], dtype='int64')
```

There are no rows where the price is more than 0 for free apps

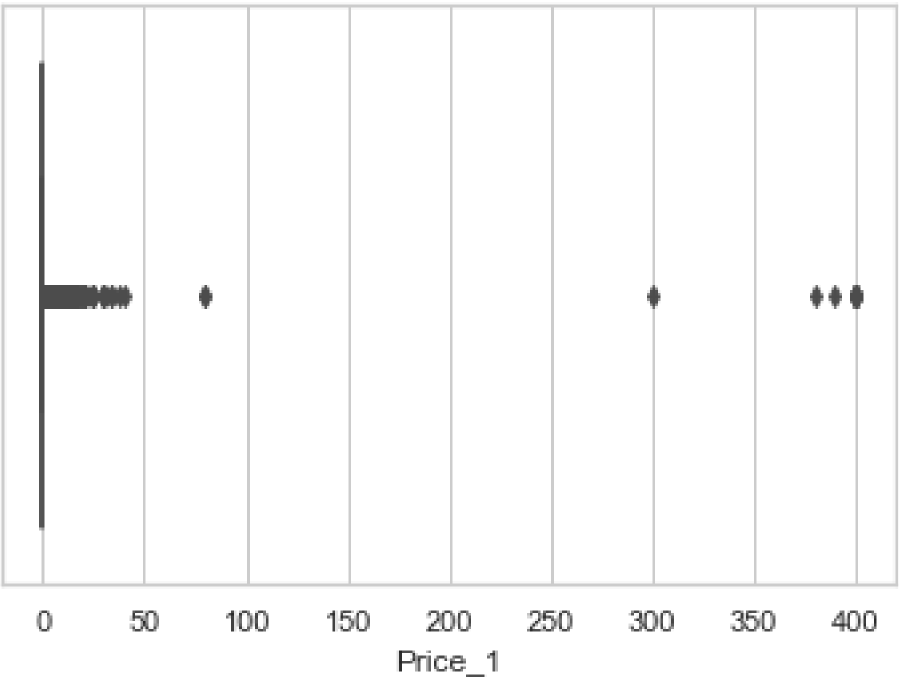
1.5 Step 5 : Performing univariate analysis:

1.5.1 Step 5 Check 1 : Boxplot for Price

```
[37]: sns.set(style="whitegrid")
```

```
[38]: sns.boxplot(x=gdata2["Price_1"])
```

```
[38]: <AxesSubplot:xlabel='Price_1'>
```

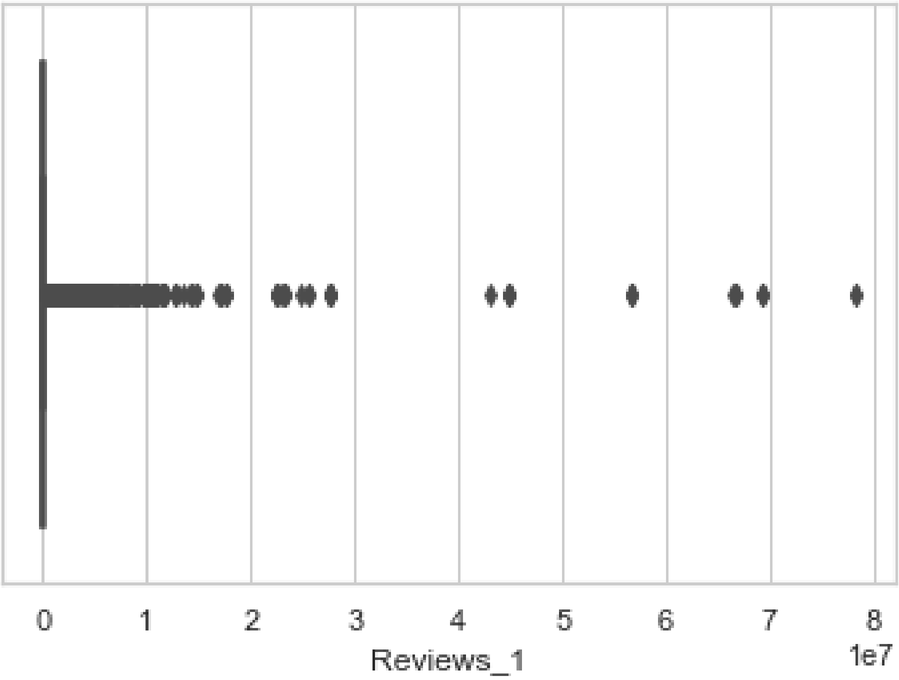


1.5.2 Step 5 Check 2 : Are there any outliers? Think about the price of usual apps on Play Store.

1.5.3 Step 5 Check 3 : Boxplot for Reviews

```
[39]: sns.boxplot(x=gdata2["Reviews_1"])
```

```
[39]: <AxesSubplot:xlabel='Reviews_1'>
```



1.5.4 Step 5 Check 4 : Are there any apps with very high number of reviews? Do the values seem right?

```
[40]: max(gdata2.Reviews_1)
```

```
[40]: 78158306
```

```
[41]: gdata2[['Reviews_1']].idxmax()
```

```
[41]: Reviews_1    2544
      dtype: int64
```

```
[42]: gdata2.loc[2544]
```

```
[42]: App                            Facebook
      Category                         SOCIAL
```

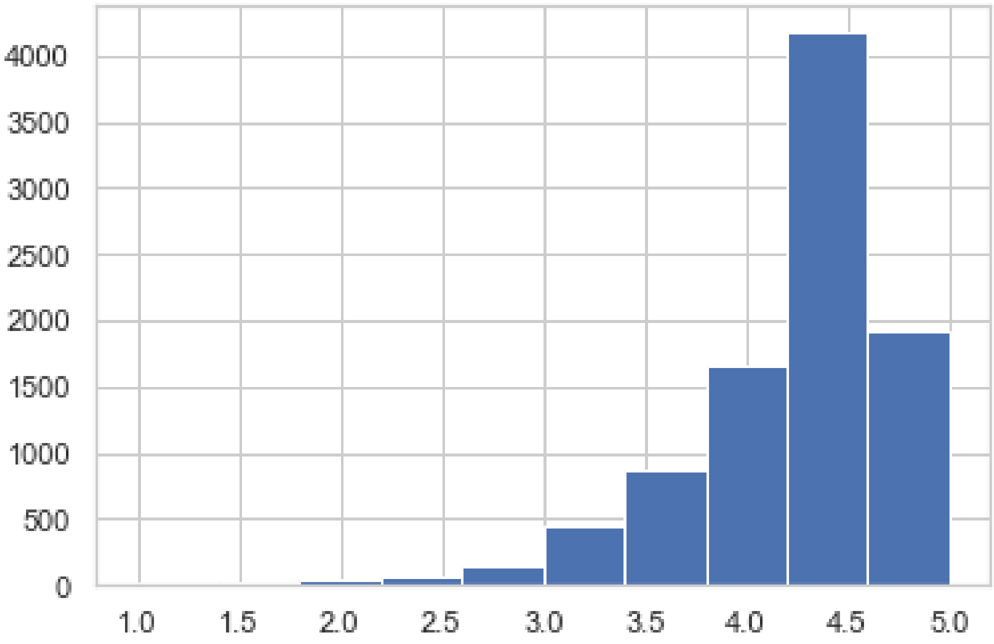
```
Rating                               4.1
Reviews                         78158306
Size                  Varies with device
Installs                  1,000,000,000+
Type                                Free
Price                                  0
Content Rating                      Teen
Genres                            Social
Last Updated              August 3, 2018
Current Ver           Varies with device
Android Ver           Varies with device
Size_1
Size_2
Size_3                               NaN
Size_4                               NaN
Size_5                      23746.316635
Reviews_1                       78158306
Installs_1                    1000000000
Price_1                              0.0
rgti                               False
Name: 2544, dtype: object
```

The highest reviews seem to be of Facebook app, which is widely used across all age groups and domains, so they seem to be right.

1.5.5 Step 5 Check 5 : Histogram for Rating

```
[43]: plt.hist(gdata2['Rating'])
```

```
[43]: (array([  17.,   18.,   41.,   74.,  137.,  445.,  879., 1660., 4172.,
              1910.]),
       array([1. , 1.4, 1.8, 2.2, 2.6, 3. , 3.4, 3.8, 4.2, 4.6, 5. ]),
       <BarContainer object of 10 artists>)
```



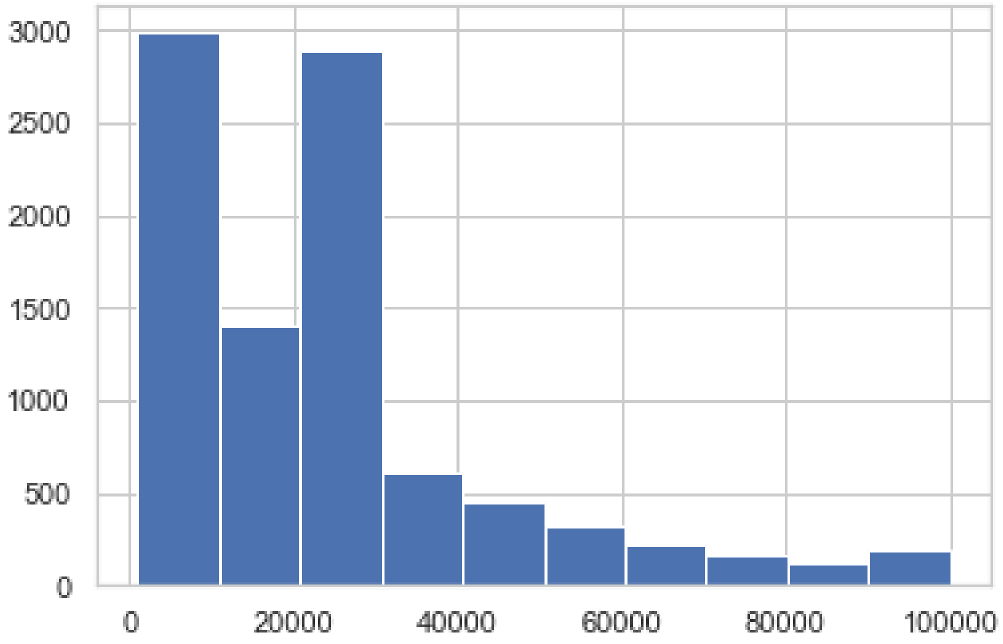
1.5.6 Step 5 Check 6 : How are the ratings distributed? Is it more toward higher ratings?

Ratings are more toward higher ratingss, but peak at 4.5

1.5.7 Step 5 Check 7 : Histogram for Size

[44]:
```
plt.hist(gdata2['Size_5'])
```

[44]:
```
(array([2988., 1398., 2884.,  606.,  449.,  325.,  226.,  161.,  117.,
         199.]),
 array([  1000.,  10900.,  20800.,  30700.,  40600.,  50500.,  60400.,
         70300.,  80200.,  90100., 100000.]),
 <BarContainer object of 10 artists>)
```



1.6 Step 6 : Outlier treatment:

1.6.1 Step 6 Substep 1 : 1. Price: From the box plot, it seems like there are some apps with very high price. A price of $200 for an application on the Play Store is very high and suspicious!

Step 6 Substep 1 Part 1 : Check out the records with very high price. Is 200 indeed a high price?

Step 6 Substep 1 Part 2 : Drop these as most seem to be junk apps

```
[45]: max(gdata2['Price_1'])
```

```
[45]: 400.0
```

```
[46]: gdata3 = gdata2[gdata2['Price_1'] <= 200.00 ]
```

```
[47]: max(gdata3['Price_1'])
```

```
[47]: 79.99
```

1.6.2 Step 6 Substep 2 : Reviews: Very few apps have very high number of reviews. These are all star apps that don't help with the analysis and, in fact, will skew it. Drop records having more than 2 million reviews.

```
[48]: max(gdata3['Reviews_1'])
```

```
[48]: 78158306
```

```
[49]: gdata4 = gdata3[gdata3['Reviews_1'] < 2000000]
```

```
[50]: max(gdata4['Reviews_1'])
```

```
[50]: 1986068
```

1.6.3 Step 6 Substep 3 : Installs: There seems to be some outliers in this field too. Apps having very high number of installs should be dropped from the analysis.

Step 6 Substep 3 Part 1 : Find out the different percentiles – 10, 25, 50, 70, 90, 95, 99

```
[51]: print("10th Percentile\n", np.percentile(gdata4['Installs_1'],q=10))
```

```
10th Percentile
 1000.0
```

```
[52]: print("25th Percentile\n", np.percentile(gdata4['Installs_1'],q=25))
```

```
25th Percentile
 10000.0
```

```
[53]: print("50th Percentile\n", np.percentile(gdata4['Installs_1'],q=50))
```

```
50th Percentile
 500000.0
```

```
[54]: print("70th Percentile\n", np.percentile(gdata4['Installs_1'],q=70))
```

```
70th Percentile
 1000000.0
```

```
[55]: print("90th Percentile\n", np.percentile(gdata4['Installs_1'],q=90))
```

```
90th Percentile
 10000000.0
```

```
[56]: print("95th Percentile\n", np.percentile(gdata4['Installs_1'],q=95))
```

```
95th Percentile
 10000000.0
```

```
[57]: print("99th Percentile\n", np.percentile(gdata4['Installs_1'],q=99))
```

```
99th Percentile
 100000000.0
```

Step 6 Substep 3 Part 2 : Decide a threshold as cutoff for outlier and drop records having values more than that

```
[58]: max(gdata4['Installs_1'])
```

```
[58]: 1000000000
```

```
[59]: gdata5 = gdata4[gdata4['Installs_1'] <= 1000000] #70th percentile
```

```
[60]: max(gdata5['Installs_1'])
```

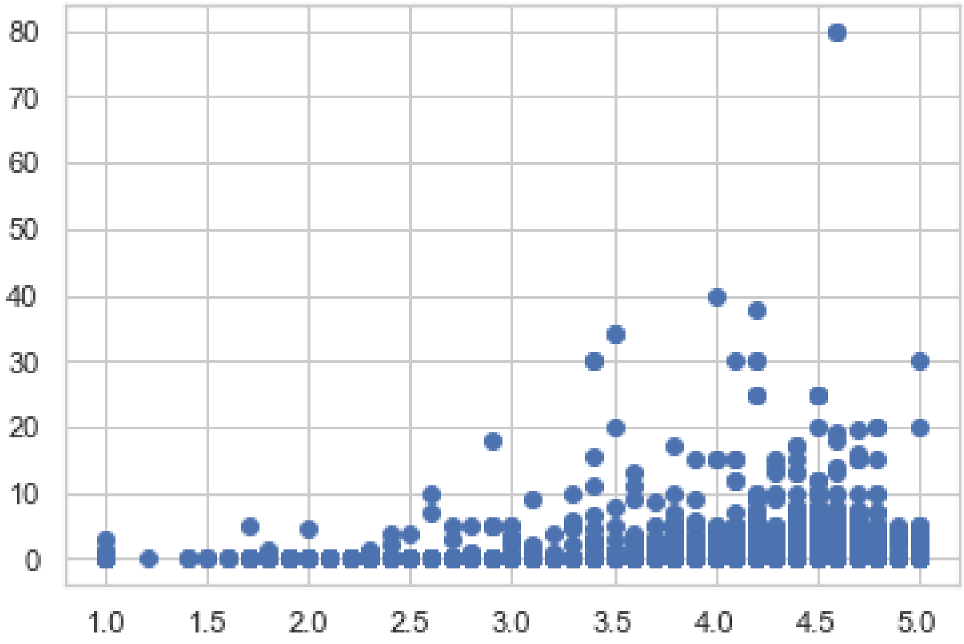
```
[60]: 1000000
```

1.7 Step 7 : Bivariate analysis: Let's look at how the available predictors relate to the variable of interest, i.e., our target variable rating. Make scatter plots (for numeric features) and box plots (for character features) to assess the relations between rating and the other features.

1.7.1 Step 7 Check 1 : Make scatter plot/joinplot for Rating vs. Price. What pattern do you observe? Does rating increase with price?

```
[61]: plt.scatter(x = gdata5['Rating'],y = gdata5['Price_1'])
```

```
[61]: <matplotlib.collections.PathCollection at 0x1d7fb683490>
```

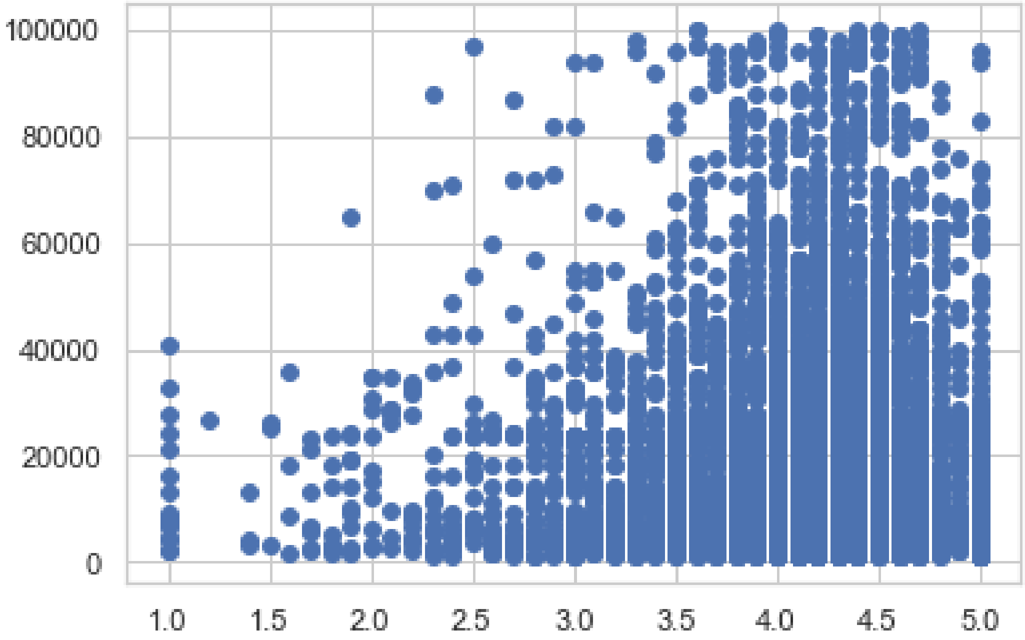


From the aabove scatter plot, ratings seem to increase with price.

1.7.2 Step 7 Check 2 : Make scatter plot/joinplot for Rating vs. Size. Are heavier apps rated better?

```
[62]: plt.scatter(x = gdata5['Rating'],y = gdata5['Size_5'])
```

```
[62]: <matplotlib.collections.PathCollection at 0x1d7f92504c0>
```

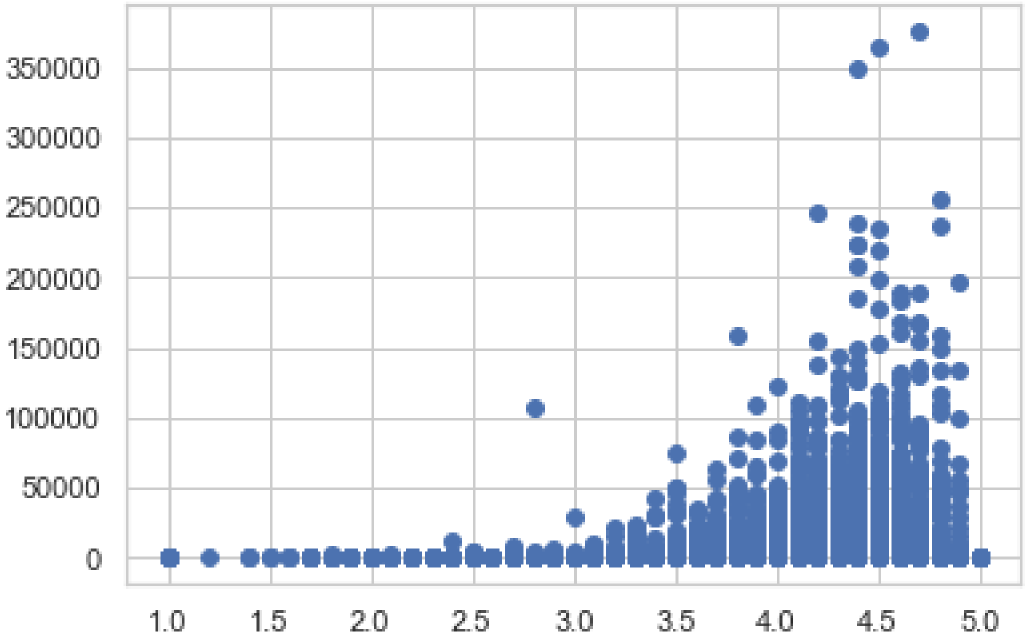


Heavier apps seem to have a higher rating than lighter apps, but there are some lighter apps which have higher rating.

1.7.3 Step 7 Check 3 : Make scatter plot/joinplot for Rating vs. Reviews. Does more review mean a better rating always?

```
[63]: plt.scatter(x = gdata5['Rating'],y = gdata5['Reviews_1'])
```

```
[63]: <matplotlib.collections.PathCollection at 0x1d7fc81c610>
```

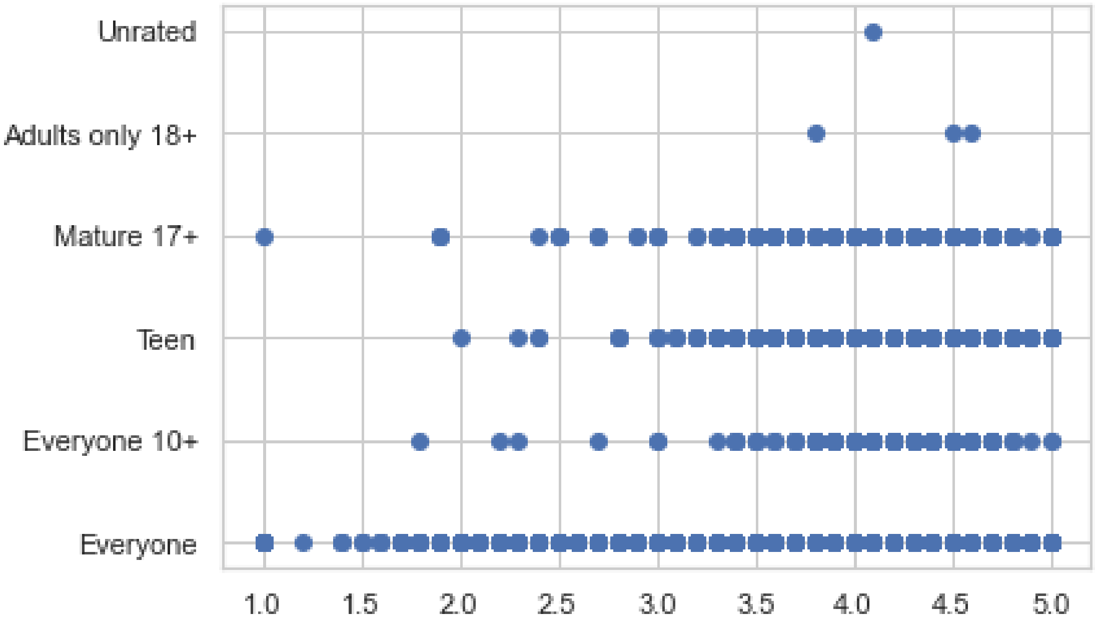


From the scatter plot above it would appear that more reviews seem to be getting a better rating than lesser rated apps.

1.7.4 Step 7 Check 4 : Make boxplot for Rating vs. Content Rating. Is there any difference in the ratings? Are some types liked better?

```
[64]: plt.scatter(x = gdata5['Rating'],y = gdata5['Content Rating'])
```

```
[64]: <matplotlib.collections.PathCollection at 0x1d7fc8a3220>
```

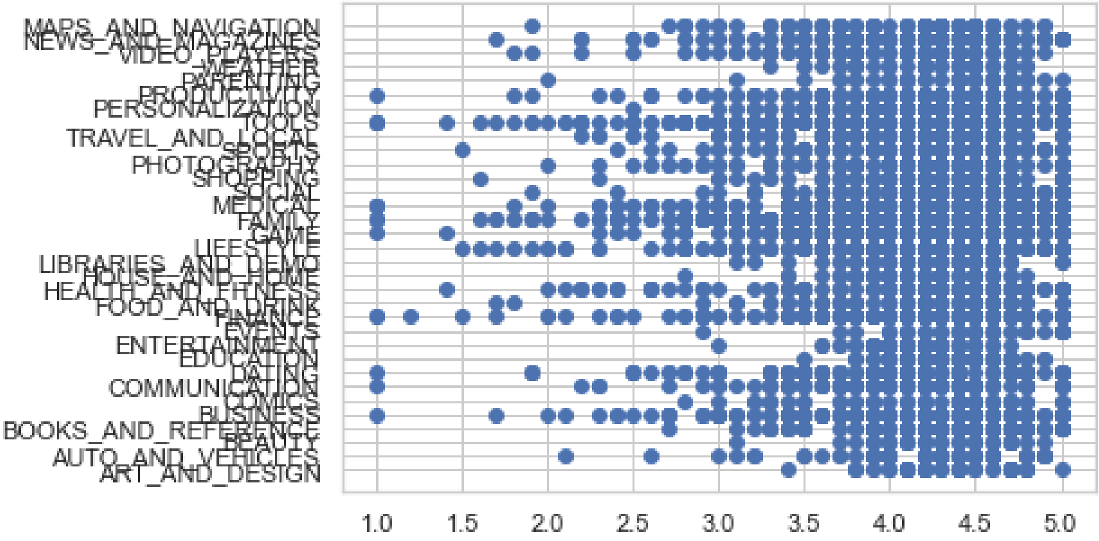


Content ratings of Mature 17+ seems to enjoy popularity across all rating classes, after Everyone.

1.7.5 Step 7 Check 5 : Make boxplot for Ratings vs. Category. Which genre has the best ratings?

```
[65]: plt.scatter(x = gdata5['Rating'],y = gdata5['Category'])
```

```
[65]: <matplotlib.collections.PathCollection at 0x1d7fc8bf610>
```



According to the scatter plot, Tools and Lifestyle seems to have the best ratings, as in each rating class is populated.

1.8 Step 8 : Data preprocessing : For the steps below, create a copy of the dataframe to make all the edits. Name it inp1.

[66]:
```
inp1 = gdata5.copy()
inp1.head()
```

[66]:
```
                                                 App        Category  Rating  \
0     Photo Editor & Candy Camera & Grid & ScrapBook  ART_AND_DESIGN     4.1
1                                Coloring book moana  ART_AND_DESIGN     3.9
4          Pixel Draw - Number Art Coloring Book  ART_AND_DESIGN     4.3
5                         Paper flowers instructions  ART_AND_DESIGN     4.4
6            Smoke Effect Photo Maker - Smoke Editor  ART_AND_DESIGN     3.8

  Reviews  Size  Installs  Type Price Content Rating  \
0     159   19M   10,000+  Free     0       Everyone
1     967   14M  500,000+  Free     0       Everyone
4     967  2.8M  100,000+  Free     0       Everyone
5     167  5.6M   50,000+  Free     0       Everyone
6     178   19M   50,000+  Free     0       Everyone

                     Genres  …   Android Ver Size_1 Size_2  Size_3 Size_4  \
0              Art & Design  …  4.0.3 and up    19M     19  1000.0   19.0
1  Art & Design;Pretend Play  …  4.0.3 and up    14M     14  1000.0   14.0
4    Art & Design;Creativity  …    4.4 and up   2.8M    2.8  1000.0    2.8
5              Art & Design  …    2.3 and up   5.6M    5.6  1000.0    5.6
6              Art & Design  …  4.0.3 and up    19M     19  1000.0   19.0

    Size_5  Reviews_1  Installs_1  Price_1   rgti
0  19000.0        159       10000      0.0  False
1  14000.0        967      500000      0.0  False
4   2800.0        967      100000      0.0  False
5   5600.0        167       50000      0.0  False
6  19000.0        178       50000      0.0  False

[5 rows x 22 columns]
```

1.8.1 Step 8 Substep 1 : Reviews and Install have some values that are still relatively very high. Before building a linear regression model, you need to reduce the skew. Apply log transformation (np.log1p) to Reviews and Installs.

[67]:
```
inp1['Reviews_2'] = np.log1p(inp1['Reviews_1'])
inp1['Reviews_2'].head()
```

[67]:
```
0    5.075174
1    6.875232
4    6.875232
5    5.123964
6    5.187386
Name: Reviews_2, dtype: float64
```

[68]:
```
inp1['Installs_2'] = np.log1p(inp1['Installs_1'])
inp1['Installs_2'].head()
```

[68]:
```
0     9.210440
1    13.122365
4    11.512935
5    10.819798
6    10.819798
Name: Installs_2, dtype: float64
```

[69]:
```
inp1['Size_5'] = np.log1p(inp1['Size_5'])
inp1['Size_5'].head()
```

[69]:
```
0    9.852247
1    9.546884
4    7.937732
5    8.630700
6    9.852247
Name: Size_5, dtype: float64
```

1.8.2 Step 8 Substep 2 : Drop columns App, Last Updated, Current Ver, and Android Ver. These variables are not useful for our task.

[70]:
```
inp1.head(1)
```

[70]:
```
                                                App        Category  Rating  \
0  Photo Editor & Candy Camera & Grid & ScrapBook  ART_AND_DESIGN     4.1

  Reviews Size Installs  Type Price Content Rating        Genres  … Size_2  \
0     159  19M  10,000+  Free     0       Everyone  Art & Design  …     19

   Size_3 Size_4    Size_5 Reviews_1  Installs_1  Price_1   rgti  Reviews_2  \
0  1000.0   19.0  9.852247       159       10000      0.0  False   5.075174
```

```
   Installs_2
0     9.21044

[1 rows x 24 columns]
```

[71]:
```
inp2 = inp1.drop(columns = ['App','Type','Last Updated','Current Ver','Android␣
 ↪Ver','Size','Size_1','Size_2','Size_3','Size_4','Reviews','Installs','Price','Reviews_1','I
inp2.head(1)
```

[71]:
```
        Category  Rating Content Rating        Genres    Size_5  Price_1  \
0  ART_AND_DESIGN     4.1       Everyone  Art & Design  9.852247      0.0

   Reviews_2  Installs_2
0   5.075174     9.21044
```

[72]:
```
inp3 = inp2.rename(columns={'Size_5':'Size','Price_1':'Price','Reviews_2':
 ↪'Reviews','Installs_2':'Installs'})
```

[73]:
```
inp1 = inp3[['Rating','Category','Reviews','Size','Installs','Price','Content␣
 ↪Rating','Genres']]
inp1.head(1)
```

[73]:
```
   Rating        Category   Reviews      Size  Installs  Price Content Rating  \
0     4.1  ART_AND_DESIGN  5.075174  9.852247   9.21044    0.0       Everyone

         Genres
0  Art & Design
```

[74]:
```
inp1.isnull().sum()
```

[74]:
```
Rating            0
Category          0
Reviews           0
Size              0
Installs          0
Price             0
Content Rating    0
Genres            0
dtype: int64
```

[75]:
```
inp1.dtypes
```

[75]:
```
Rating            float64
Category           object
Reviews           float64
Size              float64
Installs          float64
Price             float64
```

```
Content Rating     object
Genres             object
dtype: object
```

[76]:

```
inp1.replace([np.inf, -np.inf], np.nan, inplace=True)
inp1.fillna(1, inplace=True)                                 #to avoid error while␣
↪sklearn linearregression 'Input contains NaN, infinity or a value too large␣
↪for dtype('float64').'
```

1.8.3 Step 8 Substep 3 : Get dummy columns for Category, Genres, and Content Rating. This needs to be done as the models do not understand categorical data, and all data should be numeric. Dummy encoding is one way to convert character fields to numeric. Name of dataframe should be inp2.

[77]:

```
inp1.head(1)
```

[77]:

```
   Rating        Category   Reviews      Size  Installs  Price Content Rating  \
0     4.1  ART_AND_DESIGN  5.075174  9.852247   9.21044    0.0       Everyone

         Genres
0  Art & Design
```

[78]:

```
inp1['Category'].value_counts()
```

[78]:

```
FAMILY                 1366
TOOLS                   545
GAME                    522
MEDICAL                 346
FINANCE                 269
LIFESTYLE               265
BUSINESS                252
PERSONALIZATION         233
PRODUCTIVITY            213
HEALTH_AND_FITNESS      209
SPORTS                  198
NEWS_AND_MAGAZINES      175
DATING                  169
COMMUNICATION           161
PHOTOGRAPHY             145
SOCIAL                  137
BOOKS_AND_REFERENCE     137
TRAVEL_AND_LOCAL        136
SHOPPING                122
EDUCATION                99
VIDEO_PLAYERS            98
MAPS_AND_NAVIGATION      90
FOOD_AND_DRINK           79
```

```
AUTO_AND_VEHICLES        68
ENTERTAINMENT            68
HOUSE_AND_HOME           60
LIBRARIES_AND_DEMO       58
COMICS                   52
ART_AND_DESIGN           52
WEATHER                  51
PARENTING                48
EVENTS                   43
BEAUTY                   40
Name: Category, dtype: int64
```

[79]:

```
categories_to_combine =␣
 ↪['BOOKS_AND_REFERENCE','LIBRARIES_AND_DEMO','NEWS_AND_MAGAZINES','EDUCATION','COMICS']
for cat in categories_to_combine:
 inp1['Category'].replace({cat:'BOOKS_AND_EDUCATION'},inplace = True)
```

[80]:

```
categories_to_combine =␣
 ↪['MEDICAL','LIFESTYLE','HEALTH_AND_FITNESS','SPORTS','BEAUTY']
for cat1 in categories_to_combine:
 inp1['Category'].replace({cat1:'HEALTH_AND_FITNESS'},inplace = True)
```

[81]:

```
categories_to_combine =␣
 ↪['DATING','SOCIAL','EVENTS','COMMUNICATION','FAMILY','PARENTING']
for cat2 in categories_to_combine:
 inp1['Category'].replace({cat2:'SOCIAL'},inplace = True)
```

[82]:

```
categories_to_combine = ['GAME','VIDEO_PLAYERS','ENTERTAINMENT']
for cat3 in categories_to_combine:
 inp1['Category'].replace({cat3:'ENTERTAINMENT'},inplace = True)
```

[83]:

```
categories_to_combine = ['BUSINESS','FINANCE','PRODUCTIVITY']
for cat4 in categories_to_combine:
 inp1['Category'].replace({cat4:'BUSINESS'},inplace = True)
```

[84]:

```
categories_to_combine =␣
 ↪['MAPS_AND_NAVIGATION','TRAVEL_AND_LOCAL','FOOD_AND_DRINK','SHOPPING']
for cat5 in categories_to_combine:
 inp1['Category'].replace({cat5:'MAPS_AND_NAVIGATION'},inplace = True)
```

[85]:

```
categories_to_combine =␣
 ↪['PHOTOGRAPHY','ART_AND_DESIGN','HOUSE_AND_HOME','AUTO_AND_VEHICLES']
for cat6 in categories_to_combine:
 inp1['Category'].replace({cat6:'HOBBIES'},inplace = True)
```

[86]:

```
inp1['Category'].value_counts()
```

```
[86]: SOCIAL                 1924
      HEALTH_AND_FITNESS     1058
      BUSINESS                734
      ENTERTAINMENT           688
      TOOLS                   545
      BOOKS_AND_EDUCATION     521
      MAPS_AND_NAVIGATION     427
      HOBBIES                 325
      PERSONALIZATION         233
      WEATHER                  51
      Name: Category, dtype: int64
```

```
[87]: inp1['Genres'].value_counts()
```

```
[87]: Tools                                    545
      Education                                418
      Entertainment                            405
      Medical                                  346
      Finance                                  269
                                              …
      Comics;Creativity                          1
      Arcade;Pretend Play                        1
      Card;Action & Adventure                    1
      Health & Fitness;Action & Adventure        1
      Entertainment;Pretend Play                 1
      Name: Genres, Length: 108, dtype: int64
```

```
[88]: categories_to_combine = ['Books & Reference','Books & Reference;
       ↪Creativity','Books & Reference;Education','Libraries & Demo','News &␣
       ↪Magazines','Education;Education','Education','Education;
       ↪Creativity','Education;Music & Video','Education;Action &␣
       ↪Adventure','Education;Pretend Play','Education;Brain Games','Simulation;
       ↪Education','Educational;Creativity','Educational;Education','Educational;
       ↪Brain Games','Educational;Pretend Play','Entertainment;Education','Casual;
       ↪Education','Educational;Action & Adventure','Health & Fitness;
       ↪Education','Adventure;Education','Tools;Education','Parenting;
       ↪Education','Educational','Trivia;Education','Lifestyle;Education','Books &␣
       ↪Reference;Education','Puzzle;Education','Role Playing;Education','Strategy;
       ↪Education','Comics','Comics;Creativity']
      for cat in categories_to_combine:
       inp1['Genres'].replace({cat:'Books & Education'},inplace = True)
```

```
[89]: categories_to_combine = ['Medical','Lifestyle;Pretend Play','Health &␣
       ↪Fitness','Health & Fitness;Action & Adventure','Sports','Sports;Action &␣
       ↪Adventure','Beauty']
      for cat1 in categories_to_combine:
       inp1['Genres'].replace({cat1:'Health & Fitness'},inplace = True)
```

[90]:

```
categories_to_combine =␣
 ↪['Dating','Social','Events','Communication','Communication;
 ↪Creativity','Parenting','Parenting;Music & Video','Parenting;Brain Games']
for cat2 in categories_to_combine:
 inp1['Genres'].replace({cat2:'Social'},inplace = True)
```

[91]:

```
categories_to_combine = ['Action','Simulation','Casual','Arcade','Role␣
 ↪Playing','Puzzle','Adventure','Strategy','Racing','Card','Board','Word','Casino','Trivia','
 ↪Brain Games','Casual;Brain Games','Puzzle;Brain Games','Casual;Pretend␣
 ↪Play','Card;Brain Games','Board;Brain Games','Adventure;Brain Games','Role␣
 ↪Playing;Brain Games','Arcade;Action & Adventure','Racing;Action &␣
 ↪Adventure','Action;Action & Adventure','Casual;Action &␣
 ↪Adventure','Simulation;Pretend Play','Simulation;Action & Adventure','Role␣
 ↪Playing;Pretend Play','Adventure;Action & Adventure','Arcade;Action &␣
 ↪Adventure','Racing;Action & Adventure','Action;Action & Adventure','Casual;
 ↪Action & Adventure','Simulation;Pretend Play','Simulation;Action &␣
 ↪Adventure','Role Playing;Pretend Play','Adventure;Action & Adventure','Role␣
 ↪Playing;Action & Adventure','Puzzle;Creativity','Strategy;Action &␣
 ↪Adventure','Board;Action & Adventure','Casual;Creativity','Board;Pretend␣
 ↪Play','Racing;Pretend Play','Arcade;Pretend Play','Card;Action &␣
 ↪Adventure','Strategy;Creativity','Puzzle;Action & Adventure','Video Players␣
 ↪& Editors;Creativity','Video Players & Editors','Video Players & Editors;
 ↪Music & Video','Entertainment','Entertainment;Music & Video','Entertainment;
 ↪Creativity','Entertainment;Action & Adventure','Entertainment;Pretend␣
 ↪Play','Music;Music & Video','Music & Audio;Music & Video','Music']
for cat3 in categories_to_combine:
 inp1['Genres'].replace({cat3:'Entertainment'},inplace = True)
```

[92]:

```
categories_to_combine = ['Business','Finance','Productivity']
for cat4 in categories_to_combine:
 inp1['Genres'].replace({cat4:'Business'},inplace = True)
```

[93]:

```
categories_to_combine = ['Maps & Navigation','Travel & Local','Travel & Local;
 ↪Action & Adventure','Food & Drink','Shopping']
for cat5 in categories_to_combine:
 inp1['Genres'].replace({cat5:'Maps & Navigation'},inplace = True)
```

[94]:

```
categories_to_combine = ['Photography','Art & Design','Art & Design;Pretend␣
 ↪Play','Art & Design;Creativity','Art & Design;Action & Adventure','House &␣
 ↪Home','Auto & Vehicles']
for cat6 in categories_to_combine:
 inp1['Genres'].replace({cat6:'Hobbies'},inplace = True)
```

[95]:

```
inp1['Genres'].value_counts()
```

[95]:

```
Entertainment        1564
Books & Education    1005
```

```
Health & Fitness      798
Business              734
Social                556
Tools                 545
Maps & Navigation     427
Hobbies               328
Lifestyle             265
Personalization       233
Weather                51
Name: Genres, dtype: int64
```

[96]:
```
inp1['Content Rating'].value_counts()
```

[96]:
```
Everyone           5350
Teen                625
Mature 17+          314
Everyone 10+        213
Adults only 18+       3
Unrated               1
Name: Content Rating, dtype: int64
```

[97]:
```
inp2 = pd.get_dummies(data=inp1,columns=['Category','Genres','Content Rating'])
inp2.head()
```

[97]:
```
   Rating   Reviews      Size   Installs  Price  Category_BOOKS_AND_EDUCATION  \
0     4.1  5.075174  9.852247   9.210440    0.0                            0
1     3.9  6.875232  9.546884  13.122365    0.0                            0
4     4.3  6.875232  7.937732  11.512935    0.0                            0
5     4.4  5.123964  8.630700  10.819798    0.0                            0
6     3.8  5.187386  9.852247  10.819798    0.0                            0

   Category_BUSINESS  Category_ENTERTAINMENT  Category_HEALTH_AND_FITNESS  \
0                  0                       0                            0
1                  0                       0                            0
4                  0                       0                            0
5                  0                       0                            0
6                  0                       0                            0

   Category_HOBBIES  …  Genres_Personalization  Genres_Social  Genres_Tools  \
0                 1  …                       0              0             0
1                 1  …                       0              0             0
4                 1  …                       0              0             0
5                 1  …                       0              0             0
6                 1  …                       0              0             0

   Genres_Weather  Content Rating_Adults only 18+  Content Rating_Everyone  \
0               0                               0                        1
```

```
1               0                               0                        1
4               0                               0                        1
5               0                               0                        1
6               0                               0                        1

   Content Rating_Everyone 10+  Content Rating_Mature 17+  \
0                            0                         0
1                            0                         0
4                            0                         0
5                            0                         0
6                            0                         0

   Content Rating_Teen  Content Rating_Unrated
0                    0                       0
1                    0                       0
4                    0                       0
5                    0                       0
6                    0                       0

[5 rows x 32 columns]
```

1.9 Step 9 : Train test split and apply 70-30 split. Name the new dataframes df_train and df_test.

[98]:

```
inp2.head(1)
```

[98]:

```
   Rating   Reviews      Size  Installs  Price  Category_BOOKS_AND_EDUCATION  \
0     4.1  5.075174  9.852247   9.21044    0.0                             0

   Category_BUSINESS  Category_ENTERTAINMENT  Category_HEALTH_AND_FITNESS  \
0                  0                       0                           0

   Category_HOBBIES  …  Genres_Personalization  Genres_Social  Genres_Tools  \
0                 1  …                       0              0             0

   Genres_Weather  Content Rating_Adults only 18+  Content Rating_Everyone  \
0               0                               0                        1

   Content Rating_Everyone 10+  Content Rating_Mature 17+  \
0                            0                         0

   Content Rating_Teen  Content Rating_Unrated
0                    0                       0

[1 rows x 32 columns]
```

[99]:
```
df_train = inp2
df_train.head()
```

[99]:
```
   Rating   Reviews      Size   Installs  Price  Category_BOOKS_AND_EDUCATION  \
0     4.1  5.075174  9.852247   9.210440    0.0                             0
1     3.9  6.875232  9.546884  13.122365    0.0                             0
4     4.3  6.875232  7.937732  11.512935    0.0                             0
5     4.4  5.123964  8.630700  10.819798    0.0                             0
6     3.8  5.187386  9.852247  10.819798    0.0                             0

   Category_BUSINESS  Category_ENTERTAINMENT  Category_HEALTH_AND_FITNESS  \
0                  0                       0                            0
1                  0                       0                            0
4                  0                       0                            0
5                  0                       0                            0
6                  0                       0                            0

   Category_HOBBIES  …  Genres_Personalization  Genres_Social  Genres_Tools  \
0                 1  …                       0              0             0
1                 1  …                       0              0             0
4                 1  …                       0              0             0
5                 1  …                       0              0             0
6                 1  …                       0              0             0

   Genres_Weather  Content Rating_Adults only 18+  Content Rating_Everyone  \
0               0                               0                        1
1               0                               0                        1
4               0                               0                        1
5               0                               0                        1
6               0                               0                        1

   Content Rating_Everyone 10+  Content Rating_Mature 17+  \
0                            0                          0
1                            0                          0
4                            0                          0
5                            0                          0
6                            0                          0

   Content Rating_Teen  Content Rating_Unrated
0                    0                       0
1                    0                       0
4                    0                       0
5                    0                       0
6                    0                       0

[5 rows x 32 columns]
```

```
[100]: df_test = inp2.drop(['Rating'],axis=1)
       df_test.head()
```

```
[100]:     Reviews      Size   Installs  Price  Category_BOOKS_AND_EDUCATION  \
       0  5.075174  9.852247   9.210440    0.0                             0
       1  6.875232  9.546884  13.122365    0.0                             0
       4  6.875232  7.937732  11.512935    0.0                             0
       5  5.123964  8.630700  10.819798    0.0                             0
       6  5.187386  9.852247  10.819798    0.0                             0

          Category_BUSINESS  Category_ENTERTAINMENT  Category_HEALTH_AND_FITNESS  \
       0                  0                       0                            0
       1                  0                       0                            0
       4                  0                       0                            0
       5                  0                       0                            0
       6                  0                       0                            0

          Category_HOBBIES  Category_MAPS_AND_NAVIGATION  …  \
       0                 1                             0  …
       1                 1                             0  …
       4                 1                             0  …
       5                 1                             0  …
       6                 1                             0  …

          Genres_Personalization  Genres_Social  Genres_Tools  Genres_Weather  \
       0                       0              0             0               0
       1                       0              0             0               0
       4                       0              0             0               0
       5                       0              0             0               0
       6                       0              0             0               0

          Content Rating_Adults only 18+  Content Rating_Everyone  \
       0                               0                        1
       1                               0                        1
       4                               0                        1
       5                               0                        1
       6                               0                        1

          Content Rating_Everyone 10+  Content Rating_Mature 17+  \
       0                            0                          0
       1                            0                          0
       4                            0                          0
       5                            0                          0
       6                            0                          0

          Content Rating_Teen  Content Rating_Unrated
       0                    0                       0
```

```
1                     0                        0
4                     0                        0
5                     0                        0
6                     0                        0

[5 rows x 31 columns]
```

1.10 Step 10 : Separate the dataframes into X_train, y_train, X_test, and y_test.

[101]:
```
x = df_train.drop(columns = ['Rating'])
x.head()
```

[101]:
```
    Reviews      Size   Installs  Price  Category_BOOKS_AND_EDUCATION  \
0  5.075174  9.852247   9.210440    0.0                             0
1  6.875232  9.546884  13.122365    0.0                             0
4  6.875232  7.937732  11.512935    0.0                             0
5  5.123964  8.630700  10.819798    0.0                             0
6  5.187386  9.852247  10.819798    0.0                             0

   Category_BUSINESS  Category_ENTERTAINMENT  Category_HEALTH_AND_FITNESS  \
0                  0                       0                            0
1                  0                       0                            0
4                  0                       0                            0
5                  0                       0                            0
6                  0                       0                            0

   Category_HOBBIES  Category_MAPS_AND_NAVIGATION  ...  \
0                 1                             0  ...
1                 1                             0  ...
4                 1                             0  ...
5                 1                             0  ...
6                 1                             0  ...

   Genres_Personalization  Genres_Social  Genres_Tools  Genres_Weather  \
0                       0              0             0               0
1                       0              0             0               0
4                       0              0             0               0
5                       0              0             0               0
6                       0              0             0               0

   Content Rating_Adults only 18+  Content Rating_Everyone  \
0                               0                        1
1                               0                        1
4                               0                        1
5                               0                        1
6                               0                        1
```

```
   Content Rating_Everyone 10+  Content Rating_Mature 17+  \
0                            0                          0
1                            0                          0
4                            0                          0
5                            0                          0
6                            0                          0

   Content Rating_Teen  Content Rating_Unrated
0                    0                       0
1                    0                       0
4                    0                       0
5                    0                       0
6                    0                       0

[5 rows x 31 columns]
```

[102]:

```
y = df_train['Rating']
y.head()
```

[102]:

```
0    4.1
1    3.9
4    4.3
5    4.4
6    3.8
Name: Rating, dtype: float64
```

[103]:

```
x.shape
```

[103]:

```
(6506, 31)
```

[104]:

```
y.shape
```

[104]:

```
(6506,)
```

[105]:

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.
 ↪3,random_state=42)
print(x_train.shape)
print(x_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(4554, 31)
(1952, 31)
(4554,)
(1952,)
```

1.11 Step 11 : Model building :

1.11.1 Step 11 Substep 1 : Use linear regression as the technique

[106]:

```python
model = LinearRegression(n_jobs=-1)
model.fit(x_train,y_train)
```

[106]:

```
LinearRegression(n_jobs=-1)
```

[107]:

```python
print(model.intercept_)
print(model.coef_)
```

```
4.788336421585006
[ 0.17351697 -0.01861844 -0.15656045 -0.00711199 -0.01917038 -0.01862594
  0.00928445  0.13347704 -0.17510211 -0.01451077  0.07498708  0.04044487
 -0.05576174  0.0249775   0.1047881  -0.01862594 -0.07126721 -0.03969325
  0.17814967 -0.15563837 -0.01451077  0.07498708 -0.02740508 -0.05576174
  0.0249775  -0.09375881  0.03234164 -0.00979026 -0.02371323  0.04296383
  0.05195683]
```

[108]:

```python
print(df_train.columns.values.tolist())
```

```
['Rating', 'Reviews', 'Size', 'Installs', 'Price',
'Category_BOOKS_AND_EDUCATION', 'Category_BUSINESS', 'Category_ENTERTAINMENT',
'Category_HEALTH_AND_FITNESS', 'Category_HOBBIES',
'Category_MAPS_AND_NAVIGATION', 'Category_PERSONALIZATION', 'Category_SOCIAL',
'Category_TOOLS', 'Category_WEATHER', 'Genres_Books & Education',
'Genres_Business', 'Genres_Entertainment', 'Genres_Health & Fitness',
'Genres_Hobbies', 'Genres_Lifestyle', 'Genres_Maps & Navigation',
'Genres_Personalization', 'Genres_Social', 'Genres_Tools', 'Genres_Weather',
'Content Rating_Adults only 18+', 'Content Rating_Everyone', 'Content
Rating_Everyone 10+', 'Content Rating_Mature 17+', 'Content Rating_Teen',
'Content Rating_Unrated']
```

[109]:

```python
list(zip(df_train.columns,model.coef_))
```

[109]:

```
[('Rating', 0.1735169723862383),
 ('Reviews', -0.01861844237407065),
 ('Size', -0.15656045074630592),
 ('Installs', -0.00711199223571913),
 ('Price', -0.01917038447568863),
 ('Category_BOOKS_AND_EDUCATION', -0.018625944266687794),
 ('Category_BUSINESS', 0.009284451604858968),
 ('Category_ENTERTAINMENT', 0.13347703507030242),
 ('Category_HEALTH_AND_FITNESS', -0.17510210863178274),
 ('Category_HOBBIES', -0.014510768824954),
 ('Category_MAPS_AND_NAVIGATION', 0.07498707849065384),
 ('Category_PERSONALIZATION', 0.04044487398888735),
 ('Category_SOCIAL', -0.05576173553818265),
 ('Category_TOOLS', 0.024977502582783737),
 ('Category_WEATHER', 0.104788099992335),
 ('Genres_Books & Education', -0.0186259442668785),
 ('Genres_Business', -0.07126720527414562),
 ('Genres_Entertainment', -0.03969324538529741),
 ('Genres_Health & Fitness', 0.17814966536062926),
 ('Genres_Hobbies', -0.15563836587442628),
 ('Genres_Lifestyle', -0.014510768824953932),
 ('Genres_Maps & Navigation', 0.07498707849065381),
 ('Genres_Personalization', -0.027405081262517617),
 ('Genres_Social', -0.055761735538182526),
 ('Genres_Tools', 0.024977502582783792),
 ('Genres_Weather', -0.09375881196068873),
 ('Content Rating_Adults only 18+', 0.03234164318162746),
 ('Content Rating_Everyone', -0.009790264959513108),
 ('Content Rating_Everyone 10+', -0.023713228760583613),
 ('Content Rating_Mature 17+', 0.04296383010129111),
 ('Content Rating_Teen', 0.05195683239786657)]
```

[110]:
```
predictors = df_train.columns.drop(['Rating'])
predictors
```

[110]:
```
Index(['Reviews', 'Size', 'Installs', 'Price', 'Category_BOOKS_AND_EDUCATION',
       'Category_BUSINESS', 'Category_ENTERTAINMENT',
       'Category_HEALTH_AND_FITNESS', 'Category_HOBBIES',
       'Category_MAPS_AND_NAVIGATION', 'Category_PERSONALIZATION',
       'Category_SOCIAL', 'Category_TOOLS', 'Category_WEATHER',
       'Genres_Books & Education', 'Genres_Business', 'Genres_Entertainment',
       'Genres_Health & Fitness', 'Genres_Hobbies', 'Genres_Lifestyle',
       'Genres_Maps & Navigation', 'Genres_Personalization', 'Genres_Social',
       'Genres_Tools', 'Genres_Weather', 'Content Rating_Adults only 18+',
       'Content Rating_Everyone', 'Content Rating_Everyone 10+',
       'Content Rating_Mature 17+', 'Content Rating_Teen',
       'Content Rating_Unrated'],
      dtype='object')
```

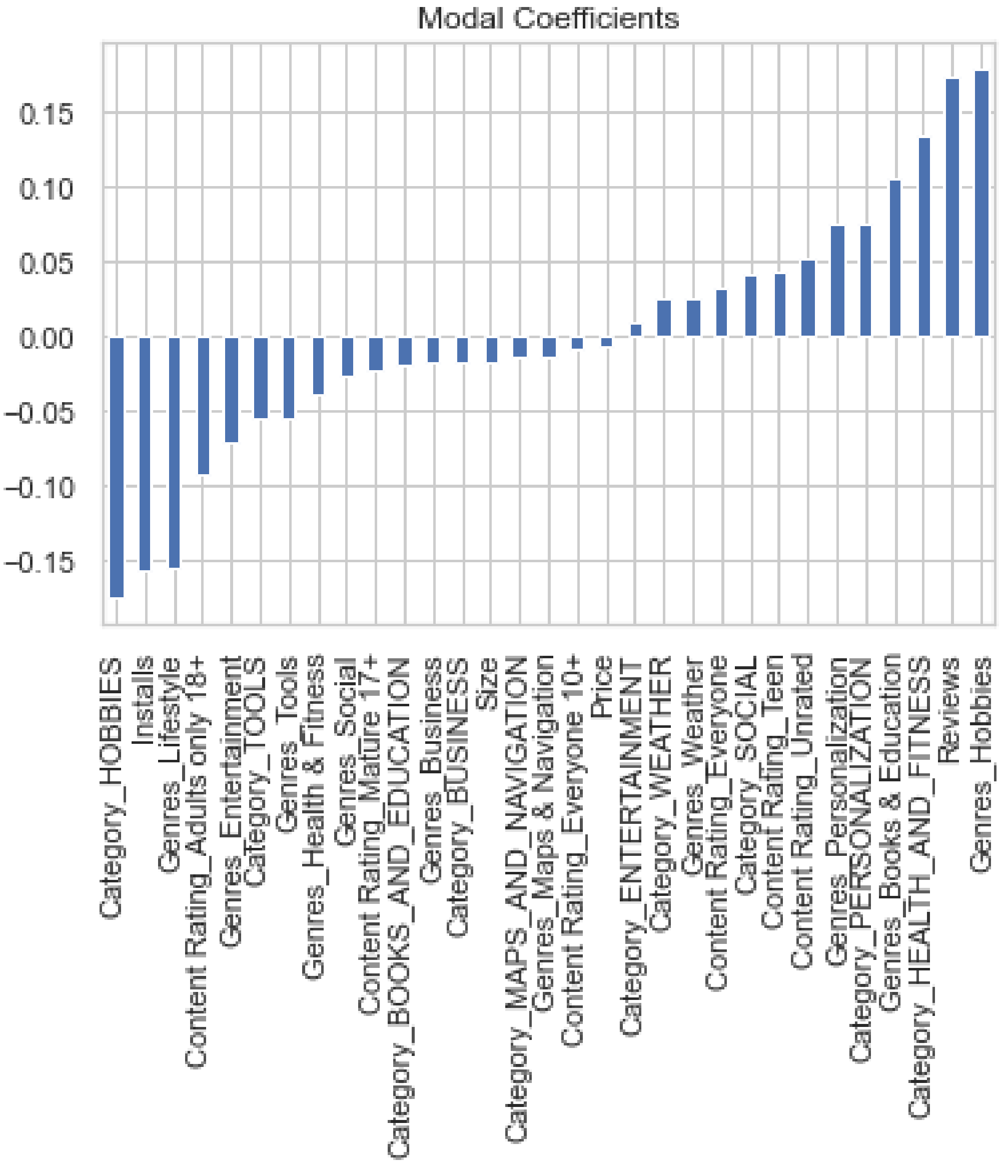
[111]:
```
coef = pd.Series(model.coef_,predictors).sort_values()
coef
```

[111]:
```
Category_HOBBIES                 -0.175102
Installs                         -0.156560
Genres_Lifestyle                 -0.155638
Content Rating_Adults only 18+   -0.093759
Genres_Entertainment             -0.071267
Category_TOOLS                   -0.055762
Genres_Tools                     -0.055762
Genres_Health & Fitness          -0.039693
```

```
Genres_Social                    -0.027405
Content Rating_Mature 17+        -0.023713
Category_BOOKS_AND_EDUCATION     -0.019170
Genres_Business                  -0.018626
Category_BUSINESS                -0.018626
Size                             -0.018618
Category_MAPS_AND_NAVIGATION     -0.014511
Genres_Maps & Navigation         -0.014511
Content Rating_Everyone 10+      -0.009790
Price                            -0.007112
Category_ENTERTAINMENT            0.009284
Category_WEATHER                  0.024978
Genres_Weather                    0.024978
Content Rating_Everyone           0.032342
Category_SOCIAL                   0.040445
Content Rating_Teen               0.042964
Content Rating_Unrated            0.051957
Genres_Personalization            0.074987
Category_PERSONALIZATION          0.074987
Genres_Books & Education          0.104788
Category_HEALTH_AND_FITNESS       0.133477
Reviews                           0.173517
Genres_Hobbies                    0.178150
dtype: float64
```

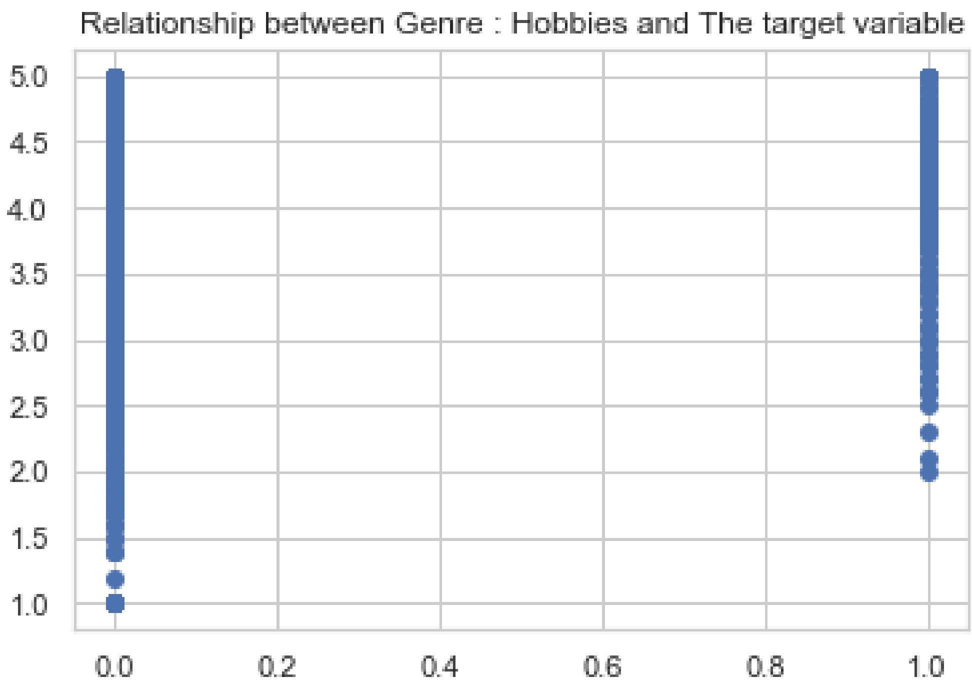
```
[112]: coef.plot(kind='bar',title = 'Modal Coefficients')
```

```
[112]: <AxesSubplot:title={'center':'Modal Coefficients'}>
```

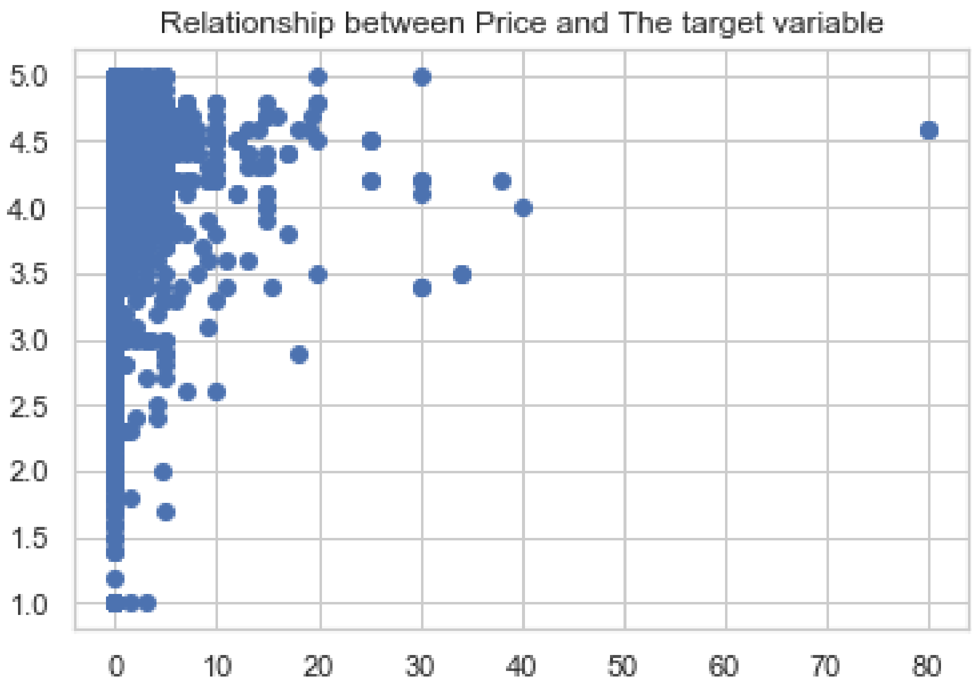


[113]:

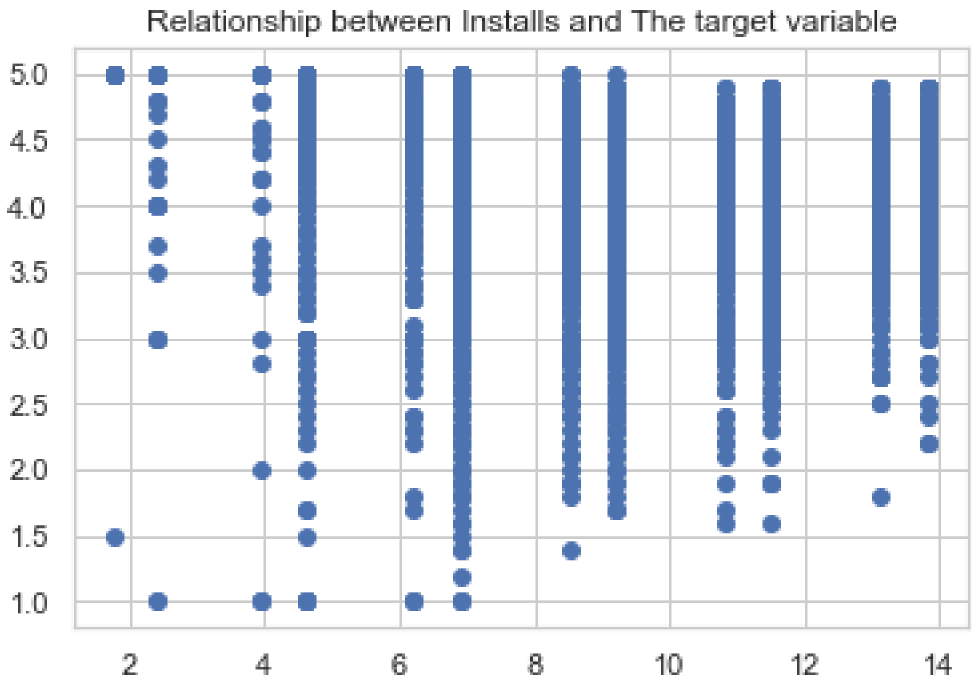
```
plt.scatter(df_train['Genres_Hobbies'],df_train['Rating'])
plt.title("Relationship between Genre : Hobbies and The target variable")
plt.show()
```



```
[114]: plt.scatter(df_train['Price'],df_train['Rating'])
       plt.title("Relationship between Price and The target variable")
       plt.show()
```



[115]:
```
plt.scatter(df_train['Installs'],df_train['Rating'])
plt.title("Relationship between Installs and The target variable")
plt.show()
```



1.11.2 Step 11 Substep 2 : Report the R2 on the train set

[116]:
```
print('R2 value/Coefficient of Determination: {}'.format(model.
 ↪score(x_test,y_test)))
```

```
R2 value/Coefficient of Determination: 0.11219554253256137
```

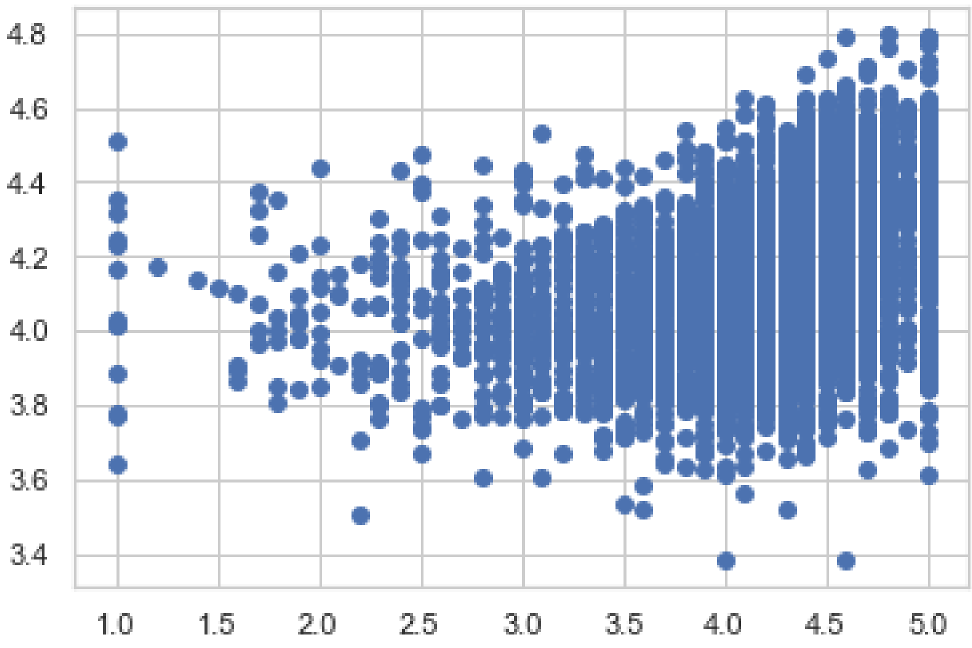
1.12 Step 12 : Make predictions on test set and report R2.

[117]:
```
model.predict(x_test)
```

[117]:
```
array([3.99011236, 4.00886209, 4.04349464, …, 4.14120839, 4.35567195,
       4.28395777])
```

[118]:
```
plt.scatter(y_train,model.predict(x_train))
```

[118]:
```
<matplotlib.collections.PathCollection at 0x1d7fcc5c6a0>
```

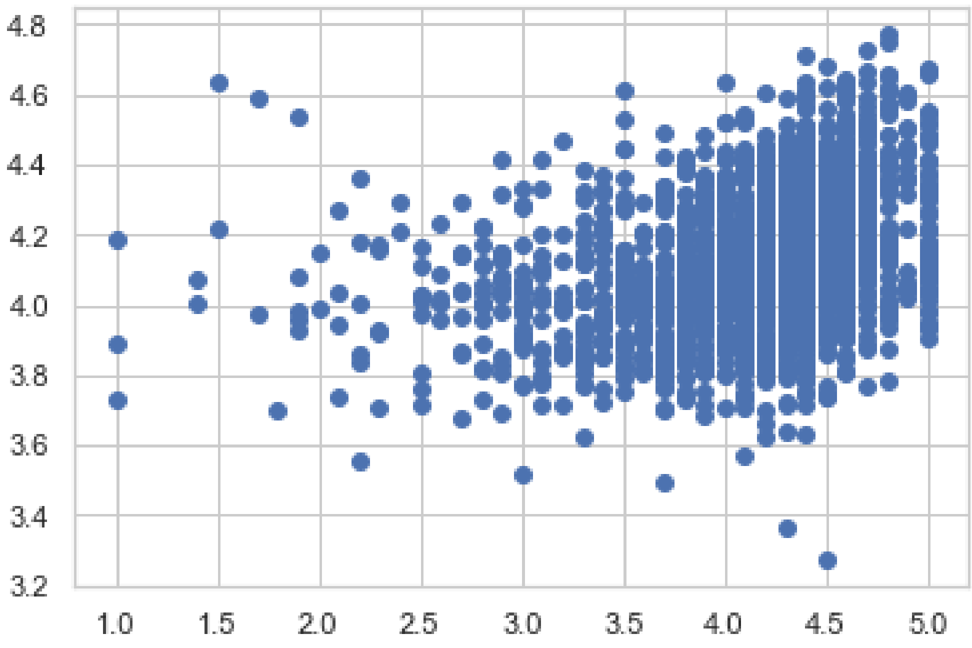


```
[119]: print(sqrt(mean_squared_error(y_train,model.predict(x_train))))
```

```
0.5516429000985769
```

```
[120]: plt.scatter(y_test,model.predict(x_test))
```

```
[120]: <matplotlib.collections.PathCollection at 0x1d7fcc6c8b0>
```



[121]:

```
print(sqrt(mean_squared_error(y_test,model.predict(x_test))))
```

```
0.5397894824642907
```

The error in x_test prediction (0.5397) is lesser than x_train prediction (0.5516) but marginally. Hence the model is acceptable, with a slight chance of overfitting.

[122]:

```
pd.DataFrame({'Actual':y_test,'Predicted':model.predict(x_test)}).head(10)
```

[122]:

```
       Actual  Predicted
6106      4.2   3.990112
8422      2.5   4.008862
8238      4.8   4.043495
6175      4.5   4.344791
110       4.3   4.027738
6050      4.4   4.214510
7413      2.4   4.211288
9356      4.6   4.147439
10318     4.4   4.139231
5568      4.2   3.845298
```

2 —X—